09/890546
JC05 d PCT/PTO 31 JUL 2001



# RADIO STATION WITH CIRCULARLY POLARIZED ANTENNA

## BACKGROUND OF THE INVENTION

The present invention relates to a radio station, which can be used especially as a base station in cellular radiotelephony systems.

More particularly, the invention relates to a radio station, comprising several antennas associated with hybrid polarizing ~~colors~~ couplers, respectively, each polarizing coupler having at least one input connected to radio signal processing means comprising at least one receiver and two outputs connected to the antenna which is associated therewith such that when said outputs deliver two quadrature radio signals, respectively, in response to a transmission signal received on one of the two inputs of the polarizing coupler, the antenna which is associated therewith generates two orthogonal electric field components forming a circularly polarized wave.

Document FR 2 746 991 discloses an arrangement of antennas in a radio station, the antennas transmitting a circularly polarized field. On reception, the waves picked up in order to produce the processed signals are linearly polarized. The receiver provides spatial diversity processing and linear polarization diversity processing in order to counteract channel fading.

In order to separate the transmitting and receiving paths, the antennas of the radiocommunication stations are associated with duplexers. In the case of circularly polarized antennas of the type described in FR 2 746 991, these duplexers are connected between the antenna and the polarizing coupler.

Documents EP 0 449 492 and "Base Station/Vehicular Antenna Design Techniques Employed in High-Capacity Land Mobile Communications System" (Y. Yamada et al, Review of the Electrical Communications Laboratories, Vol. 35, No. 2, 1st March 1987, pages 115-121), WO 96/28944 and WO 97/37441,

disclose a base station comprising antennas which are distributed in a defined geometric configuration so as to transmit a circularly polarized field.

In addition, document WO 96/28944 and WO 97/37441 disclose receiving means which are intended to provide circular polarization diversity processing.

INS M>

The aim of the present invention is, in particular, to propose other arrangements of antennas in radio stations, so as to obtain high performance in reception and/or to simplify its design and its construction.

To this end, in a radio station of the type indicated in the introduction, the receiver is arranged so as to combine several input radio signals obtained from respective inputs of the hybrid polarizing couplers, and the antennas are placed so as to radiate toward diametrically opposite sectors.

By virtue of this simple station design, the receiver processes several signals picked up on diametrically opposite sectors, these signals being obtained by mixing, in the hybrid couplers, different components of the electric field picked up by the antenna. The result of this is some smoothing of the perturbations which can affect these components, and therefore less sensitivity of the receiver to these perturbations.

Preferably, at least one of the hybrid polarizing couplers has two inputs, from which two input radio signals supplied to the receiver are respectively obtained, the receiver then being arranged so as to provide diversity processing based on said input radio signals. In this way, another form of polarization diversity is obtained in reception. Advantageously, this version makes it possible to counteract the fading effects, especially when the propagation medium creates relatively little diversity.

Where one or more duplexers are required, each of them can be connected between an input of the polarizing coupler, an input of the receiver and the

radio signal source. This gives greater flexibility in the design and the choice of antennas. In particular, the duplexer can be placed in the main housing of the radio station rather than with the antenna outside.

In particular embodiments:

- the radio station comprises two other receivers each receiving two input radio signals respectively, a first division means connected between an input of one of the hybrid polarizing couplers and first respective inputs of the two receivers, and a second division means connected between an input of another hybrid polarizing coupler and second respective inputs of the two receivers;

- the radio station comprises at least one radio signal source delivering said transmission signal to an input of a polarizing coupler.

INSA2

Other particular features and advantages of the present invention will appear in the description below of nonlimiting embodiments, with reference to the appended drawings, in which:

- figure 1 is a diagram of a radio station according to the invention having a transmitting-receiving unit;

- figure 2 is a diagram of a radio station according to the invention having two antennas and one transmitting-receiving unit;

- figure 3 is a diagram of a variant embodiment of the station of figure 2;

- figure 4 is a diagram of a radio station according to the invention having one antenna and two transmitting-receiving units;

- figure 5 is a diagram of a radio station according to the invention having two antennas and two transmitting-receiving units;

- figure 6 is a diagram of a radio station according to the invention having two antennas and four transmitting-receiving units.

INSA3

With reference to all of figures 1 to 6, the radio stations according to the invention described

here by way of example comprise either one antenna 1, or two antennas 1 and 2. Each antenna consists, for example, of two coplanar dipoles P1, P2 oriented perpendicularly to each other. By way of example, the dipole P1 may be placed horizontally and the dipole P2 vertically.

Each antenna 1, 2 is associated with a respective hybrid polarizing coupler $3_1$, $3_2$. Each of these couplers $3_1$, $3_2$ has two inputs A1, A2 and B1, B2 and two outputs, one, C1, C2 driving the dipole P1 of its associated antenna 1, 2, the other D1, D2 driving the dipole P2 of its associated antenna 1, 2.

Each polarizing coupler $3_1$, $3_2$ is chosen so that it produces two quadrature radio signals on its two outputs C1 and D1, C2 and D2. To this end, hybrid couplers, called "branch line" couplers, are used, as in patent application WO 97/37440, to which reference can be made.

The components delivered by the outputs Ci and Di of the coupler $3_i$ are thus still in quadrature one with respect to the other, such that when they drive the dipoles P1, P2 respectively of the associated antenna, the latter generates two orthogonal electric field components forming a circularly polarized wave. The left or right direction of the circular polarization depends on the polarization of the inputs Ai, Bi of the coupler from which the transmitted signal comes. Consider, for example, the case where a signal driving the input Ai of the coupler $3_i$ generates a left circularly polarized (LCP) wave, while a signal driving the other input $B_i$ of the coupler $3_i$ generates a right circularly polarized (RCP) wave.

In the exemplary embodiment shown in figure 1, where the radio station comprises one antenna 1 associated with a hybrid polarizing coupler $3_1$, the polarizing coupler $3_1$ has its input A1 connected, via a duplexer $4_1$, to a radio signal source or transmitter T1 forming part of a transmitting-receiving unit TR1, and

its input B1 connected to an input F1 of a receiver R1 forming part of said transmitting-receiving unit.

With the aim of providing circular polarization diversity processing, the duplexer $4_1$ supplies a second radio signal to another input E1 of the radio signal receiver R1. The duplexer $4_1$, associated with the polarizing coupler $3_1$, separates the transmitting and receiving paths.

This arrangement of the duplexer has the advantage, compared to the arrangement which is adopted in the radio stations of the type described in WO 97/37440, of being able to house the transmitting-receiving unit, together with the duplexer $4_1$, in the main housing 6 of the radio station, which is shown in dotted lines in figure 1, the antenna 1 and the hybrid coupler $3_1$ then being outside this housing. Consequently, the station installer will have much more freedom with regard to the design and choice of antennas. He will also be able to choose to integrate the duplexer into a microwave circuit providing other functions, such as filtering, so as to limit the costs of the radio stage.

In the exemplary embodiment shown in figure 2, the radio station comprises another antenna 2 which is associated in a similar manner with another hybrid polarizing coupler $3_2$. The antennas 1 and 2 are placed so as to radiate toward the same sector of space.

In the layout of figure 2, the polarizing coupler $3_1$ still has its input A1 connected, this time directly, to the radio signal source T1, and its input B1 connected to the input E1 of the receiver R1. As for the polarizing coupler $3_2$, it has its input A2 connected by a coaxial cable to the input F1 of the receiver R1. Its other input B2 is connected to a resistor 10 for impedance matching.

The presence of the two antennas 1 and 2 in the radio station makes it possible to combine the advantages of spatial diversity and of circularly polarized diversity in the two input signals of the

receiver R1. This is due to the fact that the radio signals supplied to the inputs E1, F1 of the receiver R1 come from non-homologous inputs B1, A2 of the polarizing couplers.

In the variant of figure 3, the signals processed by the receiver R1 come from homologous inputs B1, B2 of the two couplers such that the diversity processing applied by the receiver R1 only gives spatial diversity, possibly associated with a gain in directivity.

The layout of figure 2 or 3 is advantageous in the sense that a duplexer no longer has to be provided to separate the transmitting and receiving paths. However, depending on the performance of the coupler used and on the standing wave ratio of the antenna in the circular polarization direction used for the transmission, filters (not shown), which are smaller and less expensive than duplexers, will possibly be provided upstream of the inputs E1 and F1 of the receiver R1, in order to remove the components coupling with the powerful transmission signal.

In the embodiment shown in figure 4, the radio station comprises a single antenna 1 associated with a polarizing coupler $3_1$, and two transmitting-receiving units TR1, TR2, with a radio signal source T1, T2 and a diversity receiver R1, R2. The advantages outlined above can be fully obtained for the two transmitting-receiving units TR1, TR2.

In the layout shown, the inputs A1 and B1 of the polarizing coupler $3_1$ are connected to the radio signal sources T1, T2, respectively, via a corresponding duplexer $4_1$, $4_2$. In addition, the input A1 of the polarizing coupler $3_1$ is connected by a coaxial cable, via the duplexer $4_1$, to an input I1 of a division module $5_1$ which is included in the main housing 6 of the radio station and which is, for example, a coupler of the "Wilkinson" type, while the other input B1 of the coupler $3_1$ is in addition connected by a coaxial cable, via the duplexer $4_2$, to an input I2 of a division module

$5_2$, which is identical to the module $5_1$. The division module $5_1$ has two outputs G1, H1, one of which, G1, is connected to the input E2 of the receiver R2 and the other of which, H1, is connected to the input E1 of the receiver R1. The division module $5_2$ also has two outputs G2, H2, one of which, G2, is connected to the input F2 of the receiver R2 and the other of which, H2, is connected to the input F1 of the receiver R1. This embodiment has the additional advantage of obtaining, with only one antenna 1, a gain in polarization diversity for each of the two receivers R1 and R2. In this case too, the duplexers can be housed in the main housing 6 of the station.

The exemplary embodiment shown in figure 5 combines the advantages of the embodiments shown respectively in figures 2 and 4. In this example, there are two antennas but no duplexers. The inputs A1 and B2 of the polarizing couplers $3_1$ and $3_2$ are connected directly to the radio signal sources T1 and T2. As for the other inputs B1 and A2 of these polarizing couplers, they are connected to division modules $5_1$ and $5_2$, respectively, which are for example of the same type as those mentioned above. The division module $5_1$ has its outputs G1, H1 connected to the input E1 of the receiver R1 and to the input E2 of the receiver R2, respectively, while the division module $5_2$ has its outputs G2, H2 connected to the input F1 of the receiver R1 and to the input F2 of the receiver R2, respectively. This embodiment thus gives a gain in spatial and polarizing diversity for each of the two receivers R1 and R2 if the two antennas radiate toward the same sector of space.

An arrangement such as that of figure 5 can also be used in cells of elongate shape such as those which go along railroads or main highways. In this case, the two antennas 1, 2 are placed head to tail, so as to radiate toward two diametrally opposite sectors.

It should also be noted that, in this example, the station installer has the freedom of choosing the

option of a gain in receiving directivity instead of a gain in polarizing diversity. For this, it will be enough, for example, for him to reverse the connection of the coaxial cable which connects the input A2 of the coupler $3_2$ to the output I2 of the division module $5_2$ with the connection of the coaxial cable which connects the input B2 of the polarizing coupler $3_2$ to the radio signal source T2.

In the example shown in figure 6, the radio station comprises two antennas 1, 2 associated respectively with two polarizing couplers $3_1$ and $3_2$, two duplexers $4_1$ and $4_2$, four transmitting-receiving units TR1, TR2, TR3 and TR4 and two division modules $5'_1$ and $5'_2$. The division modules $5'_1$ and $5'_2$ have a structure similar to that of the division modules $5_1$ and $5_2$ mentioned above, with the one difference that they have four outputs G'1, H'2, J'1, K'1 and G'2, H'2, J'2, K'2, respectively, instead of two outputs. Each one may, for example, consist of three "Wilkinson" couplers arranged in two steps. The inputs A1, B1 of the polarizing coupler $3_1$ are connected to the radio signal sources T1, T2, respectively, while the inputs A2, B2 of the polarizing coupler $3_2$ are connected to the radio signal sources T3, T4, respectively. The duplexer $4_1$ is connected between the input A1 of the polarizing coupler $3_1$, the radio signal source T1 and the input I'1 of the division module $5'_1$, while the duplexer $4_2$ is connected between the input B2 of the polarizing coupler $3_2$, the radio signal source T4 and the input I'2 of the division module $5'_2$. The four outputs G'1, H'1, J'1, K'1 of the division module $5'_1$ are connected respectively to the inputs E4 of the receiver R4, E3 of the receiver R3, E2 of the receiver R2 and F1 of the receiver R1, while the four outputs G'2, H'2, J'2, K'2 of the division module $5'_2$ are connected respectively to the inputs E1 of the receiver R1, F2 of the receiver R2, F3 of the receiver R3 and F4 of the receiver R4. It is thus possible with this embodiment to increase even further the gain in polarizing diversity for the four

receivers R1, R2, R3 and R4 compared to how it was in the embodiment shown in figure 5. It is also possible to envisage, in a similar way to that described above, obtaining a gain in directivity for this embodiment, by differently connecting the coaxial cables which connect the polarizing couplers $3_1$, $3_2$ to the radio signal sources T1, T3 and T3, T4, respectively.

It goes without saying that the embodiments which have been described hereinabove have been given by way of purely indicative and nonlimiting example and that numerous modifications may be easily made by the person skilled in the art without in any way departing from the scope of the invention.

Thus, the person skilled in the art could adopt antennas whose geometry differs from that shown for the antennas 1 and 2, provided that the latter make it possible to generate two orthogonal electric field components in response to two quadrature radio signals.

Moreover, he could use various known types of polarizing couplers.